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LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT

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LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT

INTRODUCTION

The management of radioactive waste is one of the most serious environmental problems facing Canadians. From the early industrial uses of radioactive material in the 1930s to the development of nuclear power reactors and the medical and experimental use of radio-isotopes today, there has been a steady accumulation of waste products. Although the difficulties involved in radioactive waste management are considerable, responsible solutions are possible. This paper will discuss low-level radioactive waste, including its production, the amounts in storage, the rate of waste accumulation and possible strategies for its management.

DEFINITION

In Canada, low-level radioactive waste is defined as all forms of radioactive waste except spent nuclear fuel (which is high-level waste) and waste resulting from uranium mining, milling and mill tailings. Low-level waste is produced in a number of ways: the nuclear fuel cycle, including uranium processing, nuclear fuel manufacturing and electricity generation; nuclear research and radioisotope production by Atomic Energy of Canada Limited (AECL); commercial radioisotope production and use; historical activities; and decommissioning. Each of these activities will be discussed in turn.

The nuclear fuel cycle is made up of uranium processing, fuel manufacturing and electricity generation. Cameco Corporation operates Canada's only uranium refinery at Blind River, Ontario, and the only uranium conversion facilities at Port Hope, Ontario. The ore

concentrate resulting from the uranium milling process, which takes place at the mine site, is refined and made into fuel bundle by General Electric and Zircatec. The low-level radioactive waste that results from these processes includes garbage, most of which is incinerated, and contaminated metals. The companies pay to have these wastes shipped to AECL's Chalk River Laboratories, where they are stored for eventual disposal.[1]

The largest producer of nuclear-generated electricity in Canada is Ontario Hydro, which has 20 reactors in operation. Most of the waste generated by Ontario Hydro is shipped to the Radioactive Waste Operations Site at the Bruce Nuclear Power Development in Ontario but a small volume remains at the individual power station sites. The New Brunswick Power Corporation and Hydro-Québec each has one operating nuclear reactor.

Nuclear research is carried out at AECL's Chalk River and Whiteshell Laboratories. Chalk River scientists and engineers conduct research in the nuclear sciences, produce radioisotopes in the research reactors and manage low-level waste; work at Whiteshell is largely focused on management of high-level waste. Both sites have waste storage facilities, which will be discussed later.[2]

Radioisotopes, manufactured in Canada by Nordion International Inc. and AECL, are used for medical, agricultural and pharmaceutical purposes as well as for many types of scientific research. Waste is produced when the radioisotope is manufactured and sometimes, as in the case of unsealed radioisotopes tracers, when it is used. In Canada today there are approximately 4,000 licences issued by the Atomic Energy Control Board for the use of radioisotopes. Many radioisotope users ship their wastes to the Chalk River Laboratories where they pay for it to be stored.

The term "historic waste" is used to describe radioactive waste that resulted from the processing of radium and uranium ores from the 1930s to the 1950s. In these cases, wastes were managed in a way that does not conform to current safety standards. Since the original producers of this waste cannot be held responsible, the federal government has assumed responsibility for its eventual disposal.

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(1) Low-level Radioactive Waste Management Office, *Inventory of Low-Level Radioactive Waste in Canada*, Annual Report, Ottawa, 1991, p. 4.

(2) *Ibid.*, p. 5.

RECYCLED RECYCLÉ

Finally, waste is generated when a nuclear reactor is closed down at the end of its useful life and decommissioned, a process that was performed on a limited basis for the demonstration reactors Gentilly-1 in Quebec and the Douglas Point and NPD reactors in Ontario.

INVENTORY OF LOW-LEVEL RADIOACTIVE WASTE IN CANADA

A classification system has been developed that divides low-level radioactive waste into three categories, depending on source. **Generators** are waste producers still operating; this means they are responsible for the management of the waste they produce and that already in storage; these are current sources of radioactive waste. The **Historical Activities** category includes former sources of waste that are not being managed acceptably and whose originators are no longer functioning or cannot "reasonably be held responsible for the management of the waste they generated." Finally, the **Decommissioning** category includes future sources of waste that will result from the decommissioning of facilities involved in the nuclear fuel cycle and radioisotope applications. A small amount of such waste already exists.[3]

The latest figures indicate that there are about 1,300,000 cubic metres of low-level radioactive waste currently in storage in Canada. As Figure 1 shows, nearly 90% of this stems from historical activities, while 10% is produced by current generators. Decommissioning accounts for less than 1%, as there has not yet been a complete dismantling of any large facilities.[4]

Figure 2 shows that waste stemming from historical activities is only a small part of all low-level radioactive waste being generated today. Decommissioning accounts for a larger part but remains a relatively small factor in the production of new waste. The amount indicated, which comes from the dismantling of research facilities and environmental remediation, will increase to an average of 5,000 cubic metres of waste per year when commercial reactors are dismantled, a process expected to begin around 2010. The Generator category, as defined above, accounts for nearly 90% of new waste.

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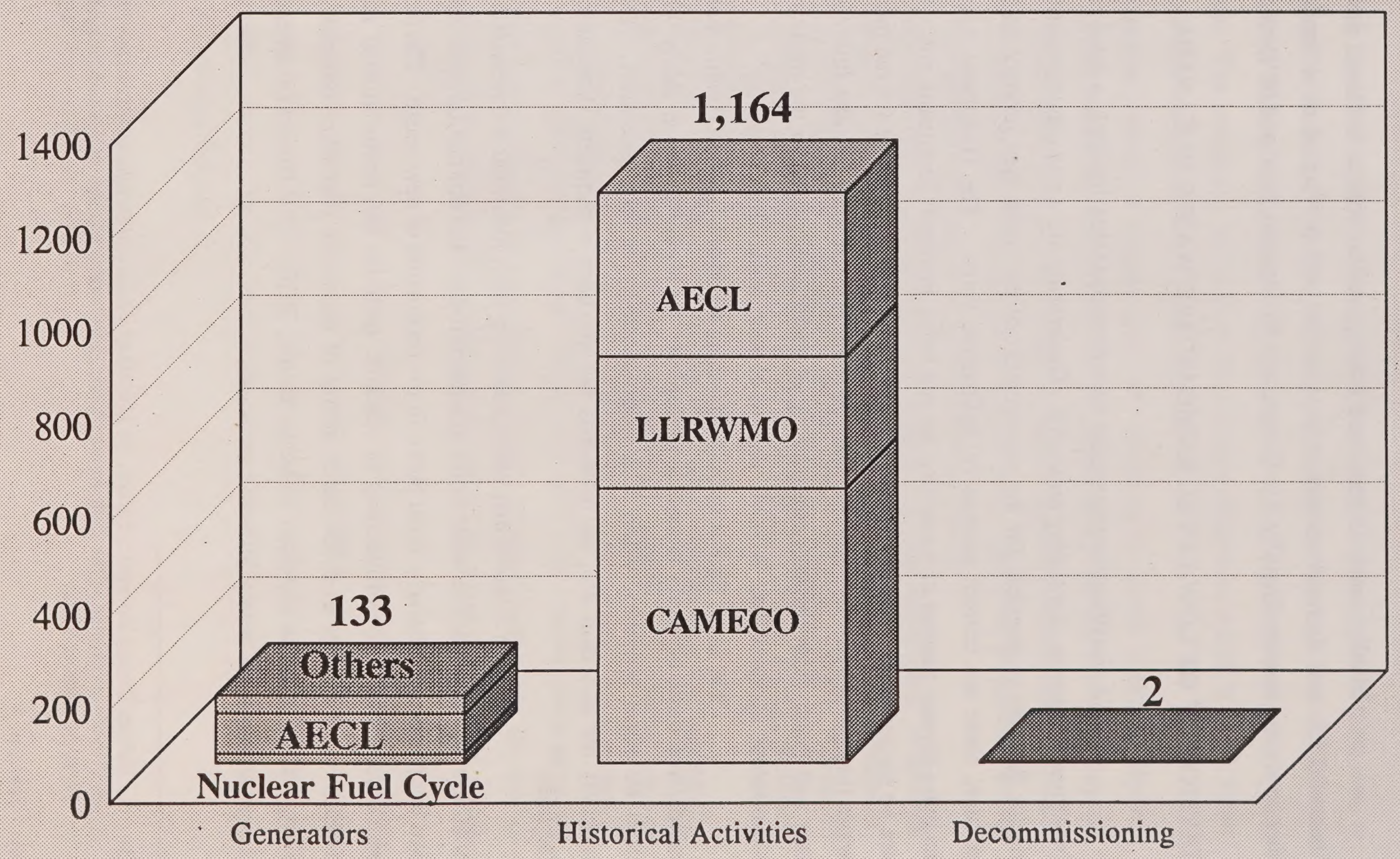
(3) L. Pabitra De and Robert C. Barker, *An Update of a National Database of Low-level Radioactive Waste in Canada*, presented at the 14th Annual DOE Low-level Radioactive Waste Management Conference, 18-20 November 1992.

(4) *Ibid.*, p. 3.

Figure 1

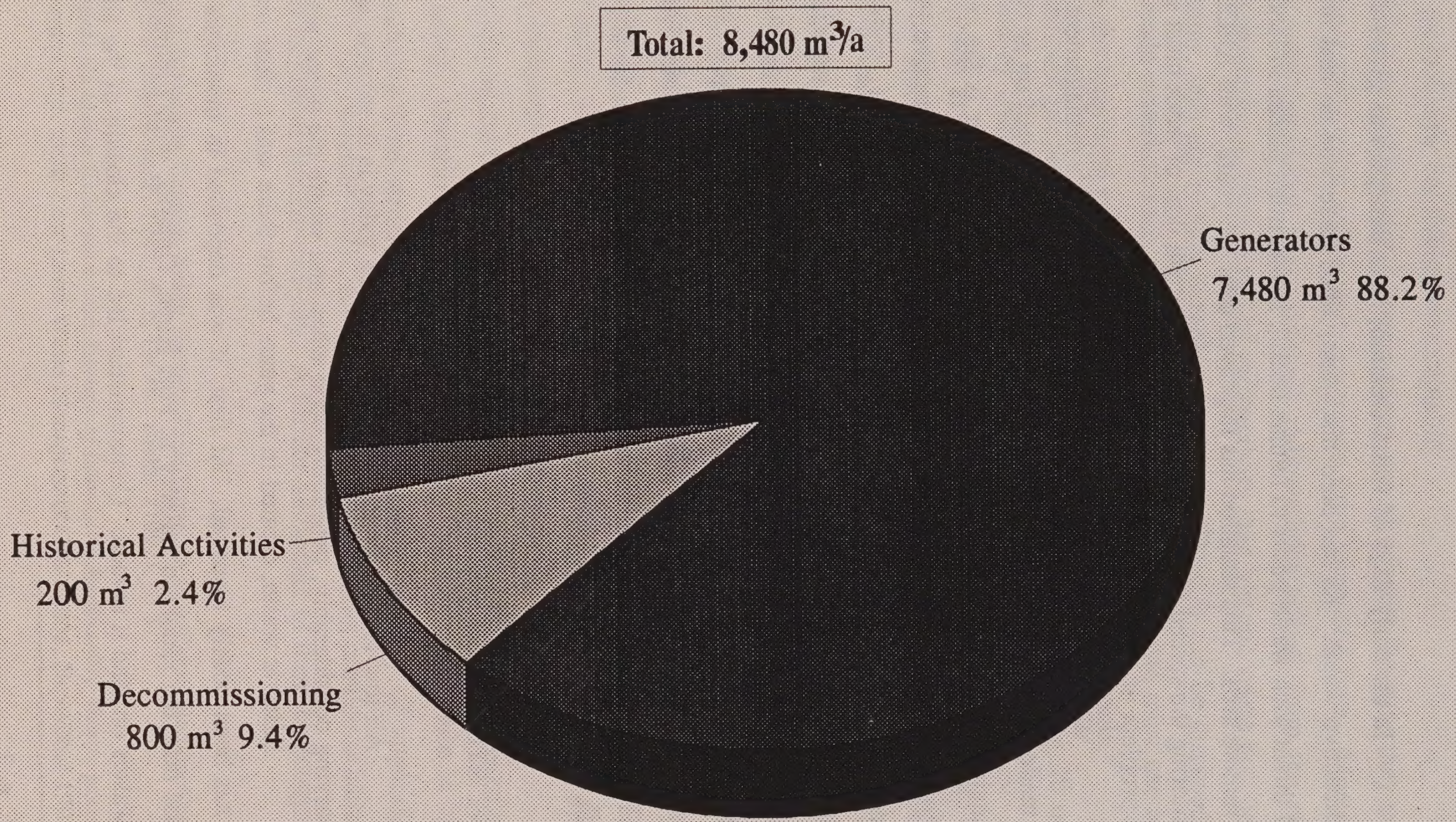
LLRW INVENTORY BY SOURCE CATEGORY



Source: *Inventory of Low-Level Radioactive Waste in Canada*, Annual Report 1991.

Figure 2

LLRW ACCUMULATION RATE BY SOURCE CATEGORY



Source: *Inventory of Low-Level Radioactive Waste in Canada*, Annual Report 1991.

RESPONSIBILITY FOR LOW-LEVEL RADIOACTIVE WASTE

In the early days of waste creation, little thought was given to disposing of low-level radioactive waste. As has been discussed, since there was no real understanding of the potential threat such waste poses to human health, it was often placed in landfill sites or simply left in a remote area. This situation has improved over the years, with AECL building trenches and monitoring the spread of the waste; however, a great deal of work must still be done to deal with the problem of low-level radioactive waste.

When discussing the responsibility for the waste's management, a clear distinction must be made between historic waste and waste still being generated on an ongoing basis. The latter remains the responsibility of its producers, while the former is the responsibility of the federal government. In 1982, AECL created the Low-Level Radioactive Waste Management Office and gave it the mandate to resolve the historic waste problem. This office operates as a distinct unit within AECL and takes advantage of that company's technical expertise while remaining independent of its other roles.(5) The office also answers public information questions about low-level radioactive waste, and is developing a user-pay service for disposing of the waste created on an ongoing basis. Funding for the office comes from Energy, Mines and Resources Canada, the department responsible for establishing a national policy for low-level radioactive waste management.

PRESENT STORAGE CONDITIONS

All low-level radioactive waste in Canada today is in storage, with the method of storage varying considerably, depending upon when and where the waste was created.

Historic waste, created in the years before there was a clear understanding of its dangers, has been poorly managed. At first, it was deposited in municipal landfill sites and vacant land near the Eldorado refinery in Port Hope, Ontario, with Eldorado later placing its refinery wastes on land it owned. Contamination led to the closure of the site near Welcome,

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(5) *Ibid.*, p. 2.

RECYCLED RECYCLÉ

Ontario, and its relocation near Port Granby. Eldorado routinely used near-surface burial for its waste disposal, a method now considered unacceptable.

In addition to radioactivity, historic wastes are of concern because they contain a number of toxic heavy metals that will remain hazardous for a very long time. Most of the low-level radioactive waste produced today contains radionuclides arising from the nuclear fission process. This waste has a higher level of radioactivity than historic waste but, because the half-lives are shorter, will not remain hazardous as long. Thus, it can be disposed of in facilities using man-made materials such as concrete, whereas historic waste must use natural and geological media for long term containment of radioactive and toxic materials.(6)

A significant proportion of the low-level waste is generated at the 20 nuclear power reactors operated by Ontario Hydro and from the research laboratories of AECL. All of this waste has been stored at Ontario Hydro's Bruce Nuclear Power Development site or the Chalk River Laboratory site of AECL, to avoid the problem of having many small sites.

For 20 years, Ontario Hydro has stored its low-level waste from all three power plants at the Bruce Nuclear Power Development site, located 200 kilometres north-west of Toronto. In storing the waste, four basic principles are followed. The facilities are designed to last a maximum of 50 years and materials must be retrievable from them. Radioactive materials cannot be placed directly in the earth but must be in an engineered structure. Only solids are placed in storage; liquids must first be immobilized to ensure they do not spread into the environment. Finally, waste storage is recognized as temporary; no permanent disposal method for low-level radioactive waste has yet been implemented.(7)

Depending on the radioactivity of the waste, a variety of different types of storage facilities are in use today. Ontario Hydro places almost all of its low-level waste in "above-ground modular warehouse type structures, each with a storage capacity of approximately 280,000 cubic feet."(8) The concrete walls, roof and floor of the building provide shielding and the waste is placed to maximize storage capacity. A further advantage of these buildings is that

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(6) Energy, Mines and Resources Canada, Siting Process Task Force on Low-Level Radioactive Waste Disposal, *Opting for Co-operation*, 1987, p. 1; De and Barker (1992), p. 7.

(7) Pollock and Zelmer, *Canadian Experience with Storage of Low-Level Radioactive Waste*, presented at the Thirteenth Annual U.S. DOE Low-Level Waste Management Conference, November 1991, p. 5.

(8) *Ibid.*

waste can be "cascaded"; that is, it can be stored elsewhere until its activity level drops, when it can be transferred to a storage building. The first such structure was put in place in 1982. Another type of above-ground facility are quadricells: reinforced concrete modules consisting of two independent envelopes with a monitored interspace, designed to hold resins from storage tanks.

Concrete trenches were one of the early methods of storing low-level waste. Trenches, approximately 130 feet long, 23 feet wide and 10 feet deep, are placed in areas where the soil has low permeability to ensure the slow migration of any radionuclides that escape. When full, the trenches are covered by one-foot thick concrete lids. The concrete tile hole, another type of in-ground structure, is formed by excavating a hole, and placing a section of precast pipe sections on a concrete base. After these are carefully attached, the excavation is backfilled and paved over. Steel liners were introduced to deal with early problems of water leakage.(9)

At Chalk River, where low-level waste has been stored since 1946, many of the same disposal methods are used. Concrete bunkers contain waste that can be handled safely without protective shielding and in-ground concrete pipes are used for wastes with a higher level of radioactivity. The main aim is to advance from this type of temporary storage to a permanent disposal system.

At the Chalk River Laboratories a number of storage concepts are in use. Sand trenches are used for storage of low-hazard material. Both in-ground and above-ground cylindrical concrete structures, similar to those used by Ontario Hydro, are used for higher activity materials that require radioactive shielding.

Scientists at Chalk River are also developing methods to assess and deal with the problem of waste disposal at old storage sites that do not meet today's safety standards. At these sites, which are extensively monitored, contamination is spread over large areas, which must now be dealt with.

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(9) *Ibid.*, p. 6.

POSSIBLE METHODS OF WASTE DISPOSAL

The main difference between storage and disposal is one of intent. Waste in storage is monitored, with the possibility that it could be retrieved; waste in a disposal facility remains there for the indefinite future, without surveillance. No decision has been made on the type of disposal facility that will be used for low-level radioactive waste but AECL has developed and demonstrated a few methods and has studied three concepts. The Improved Sand Trench would be used for wastes that need isolation for up to 150 years. The Intrusion Resistant Underground Structure (IRUS), in which most of the waste will be stored, could hold wastes for up to 500 years and the Shallow Rock Cavity could contain wastes that should be isolated for even longer.(10)

Scientists and engineers at the Chalk River laboratories started the IRUS development and demonstration program. The facility will be made up of an underground concrete vault located above the water table in a sand formation on AECL property at Chalk River.(11) The concrete vault will provide approximately 4,000 cubic metres of space for waste and backfill. To ensure that nobody inadvertently breaks into the facility, it will have a thick concrete cover, which, tests indicate, will remain intact for over 500 years. Drainage barriers will be put in place to direct water away from the disposal unit. Water that does seep into IRUS will pass through a porous bottom layer, which will remove the radionuclides.

Much background work has gone into the development of IRUS in order to ensure that the facility, once it is finished, will receive a licence from the Atomic Energy Control Board (AECB). The regulatory requirement is that "serious health risks to individuals be less than one in a million per year as a result of migration of nuclides from the waste through pathways in the environment, or by inadvertent intrusion into the waste."(12) The IRUS design is currently under regulatory review by the AECB.

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(10) L.P. Buckley and D.H. Charlesworth, "AECL Experience with Low-Level Radioactive Waste Technologies," *AECL-9787*, August 1988, p. 5.

(11) International Atomic Energy Agency, *Review of Available Options for Low Level Radioactive Waste Disposal*, July 1992, p. 41.

(12) *Ibid.*

REGULATORY QUESTIONS

Any low-level radioactive waste facility constructed in Canada must be be regulated by the Atomic Energy Control Board. This federal agency issues licences and regulates all nuclear-related facilities. Having issued the regulations and associated documents, however, the AECB makes the licensee responsible for the safety of the facility and establishes a number of guidelines to which the operator of the facility must adhere. In general, it is the responsibility of the licensee to explain to the AECB how it plans to meet its performance criteria, and how safety will be assured. Considerable effort will be needed to ensure that the public has input into decisions, both on the type of waste facility needed and where it should be located.

DISPOSAL OF HISTORIC WASTES

Determining the location of the long-term disposal site for low-level radioactive waste continues to be the most difficult issue. For example, in 1980 the Atomic Energy Control Board directed Eldorado Nuclear, the Crown company that processed uranium in the Port Hope area from 1948 to 1955, to decommission the nearby Port Granby site in order to prevent waste at this site from eventually eroding into Lake Ontario. Community opposition led the government to cancel an attempt to find a permanent disposal site in the Port Hope area, and instead establish an independent task force (the Siting Process Task Force on Low-Level Radioactive Waste Disposal) to develop a process to resolve the siting problem for most of the historic waste.

The Task Force's final report, *Opting for Cooperation*, recommended that communities should have greater participation in determining where the waste should be placed. The process would include joint planning, information sharing and community participation in decision-making. The community would also be compensated both for participating in the process and for housing the waste facility.(13)

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(13) R.W. Morrison and P.A. Brown, *Radioactive Waste Management in Canada*, presented at the Uranium Institute Sixteenth Annual Symposium, September 1991, p. 9; see also *Opting for Cooperation* (1987).

In response to this report, the federal government appointed a second task force, the Siting Task Force on Low-Level Radioactive Waste Management, to work towards finding a solution to the problem of historic waste. Since its work began in 1988, the task force has consulted with 14 communities; of the six that at first decided to go on with the process, two, at Geraldton, Ontario, and at Deep River, Ontario, are continuing to do so. The remaining phases include a technical review and environmental assessment of the management options, which, it is hoped, will lead to having one community hosting the historic waste facility. The disposal of the waste still being generated remains the responsibility of the producers. No disposal site has yet been determined by AECL and Ontario Hydro, the largest generators of low-level radioactive waste.

CONCLUSION

The search to find a safe and acceptable low-level radioactive waste management facility continues in this country. Although a great deal of scientific work must be carried out to develop the optimum long-term disposal system, the most difficult outstanding problem is to determine its site. For historic waste, a careful process is being followed to try to ensure wide community involvement in choosing the type of facility and its location. Much work remains to be done, however, in how to dispose of waste still being produced.

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